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(54) LOW-COST LEAD-FREE DEZINCIFICATION-RESISTANT BRASS ALLOY FOR CASTING

(57) A low-cost lead-free dezincification corrosion-resistant brass alloy for casting. The brass alloy contains : 60-65 wt.% of Cu, 0.05-0.25 wt.% of Pb, 0.05-0.8 wt.% of Al, 0-0.1 wt.% of Sn, and 0.05-0.16 wt.% of As, with the balance being Zn and inevitable impurities. Moreover, the equivalent weight of zinc X meets the requirements of the following formula: 35% < X < 39.5%, and X = (B+ ∑ CiKi)/(A+B+ ∑ CiKi); in the formula, X is the equivalent weight of zinc in the complex brass, A is the copper content (%), B is the actual zinc content (%), Ci is the content (%) of the other alloy elements, and CiKi is the corresponding equivalent weight of zinc of various elements.

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Description

TECHNICAL FIELD

[0001] The present invention belongs to the technical field of alloys, particularly relates to an environmentally-friendly lead-free brass alloy, more specifically relates to a low-cost lead-free dezincification-resistant brass alloy for casting.

BACKGROUND OF THE INVENTION

[0002] It is well known that there exists selective corrosion (i.e., dezincification phenomenon) during use of brass, therefore as an important index of the brass alloy material, the superior dezincification corrosion resistance is very important for improving the service life of parts or equipment. The normal copper alloys containing lead exhibit low dezincification corrosion resistance, for example, the average dezincification layer depth of the lead copper CuZn39Pb1Al is greater than 400 μm. As for dezincification-resistant capacity of brass products, it is generally accepted internationally the AS 2345 standard, that is the average dezincification layer depth of brass products should not exceed 100 μm.

[0003] There are two main problems existing in the dezincification corrosion resistance brass on the market: High lead content: the widely used DR brass for casting CuZn35Pb2Al on the market contains Pb with a content of 1.5-2.2wt.%.

[0004] High copper content: some known copper alloys, such as H85A, H70A and C69300, do not contain Pb, which meet the requirement for environmental protection, however, the cost of the copper alloys is high because of their high copper content.

[0005] The brass alloy with low copper content is mainly composed of $\alpha + \beta$ two-phase brass. The addition of As can significantly improve its dezincification corrosion resistance. So far, there have been some patent applications claiming adding a certain amount of As to brass to improve its dezincification corrosion resistance.

[0006] Chinese patent application No. 201110389789.0 discloses a low lead corrosion resistant brass alloy for casting and the manufacturing method thereof, the brass alloy consists of 61.0-62.5wt.% of Cu, no more than 0.2wt.% of Pb, no more than 0.2wt.% of Al, 0.35-0.55wt.% of Bi, 0.15-0.22wt.% of As, no more than 0.15wt.% of impurities, and the balance being Zn.

[0007] PCT patent application No. WO/2001/014606 discloses a dezincification-resistant brass alloy for die-casting consisting of 63.0-65.0wt.% of Cu, 1.5-2.2wt.% of Pb, 0.6-0.9wt.% of Si, 0.03-0.1wt.% of Al, 0.03-0.1wt.% of As, < 0.5wt.% of Ni, < 0.5wt.% of Sn, 0.1-0.5wt.% of Fe, 0-15ppm of B, < 0.3wt.% of the sum of other impurities, and the balance being Zn.

[0008] Chinese patent application No.200910164116.8 discloses a low lead dezincification-resistant brass alloy consisting of less than 0.3wt.% of Pd, 0.02 to 0.15wt.% of Sb, 0.02 to 0.25wt.% of As, 0.4 to 0.8wt.% of Al, 1 to 20ppm of B, more than 97wt.% of Cu and Zn, wherein the content of Cu in the dezincification-resistant brass alloy is 58 to 70 wt.%.

[0009] Chinese patent application No. 200910171021.9 discloses a dezincification-resistant copper alloy and the manufacturing method thereof, wherein the brass alloy consists of 59.5 to 64wt.% of Cu, 0.1 to 0.5wt.% of Bi, 0.08 to 0.16wt.% of As, 5 to 15ppm of B, 0.3 to 1.5wt.% of Sn, 0.1 to 0.7wt.% of Zr, less than 0.05wt.% of Pb, and the balance being Zn.

[0010] Chinese patent application No. 201010502728.6 discloses a dezincification-resistant brass alloy consisting of 0.5 to 1.2wt.% of Si, 0.01 to 0.2wt.% of Sb, 0.02 to 0.25wt.% of As, 0.4 to 0.8wt.% of Al, and more than 95.8wt.% of Cu and Zn.

[0011] Lead will pollute the environment and threaten human health in the process of production and use. Developed countries and districts such as the United States and the European Union have successively formulate the standards and regulations, such as NSF-ANSI372, AB-1953, and RoHS and the like, to gradually prohibit producing, selling and using leaded products. Sb is toxic itself and is very easy to release in the process of use, and the release amount of Sb into water of the products such as the tap, valve and the like is far beyond the standard tested by NSF, therefore, the use of Sb exists hidden dangers for environment and human health. Bi is expensive, and has to be strictly separated from leaded brass and other metals in the scrap recycling chain, which is difficult to control. Zr is expensive, and very easy to combine with oxidizing mediums like oxygen, sulphur and the like to transfer into the slag, which cause great loss.

SUMMARY OF THE INVENTION

[0012] In order to overcome the drawbacks of the prior art, the invention provides a low cost lead-free dezincification-resistant brass alloy for casting. The brass alloy of the present invention has good comprehensive performance and can be used for producing components such as water taps, conduit joints and the like. The alloy of the present invention has excellent dezincification corrosion resistance, and its average dezincification layer depth is less than 100μm. In addition, the alloy also has good castability, stress corrosion resistance, polishing performance and welding performance, is suitable for the components such as plumbing, bathroom and the like molded by sand casting and low pressure casting, especially for accessories such as water taps and the like working in poor environment condition.

[0013] The purpose of the present invention is achieved through the following technical solutions.

[0014] The present invention provides a low cost lead-free dezincification-resistant brass alloy for casting, wherein the brass alloy contains 60-65wt.% of Cu, 0.05-0.25wt.% of Pb, 0.05-0.8wt.% of Al, less than 0.1wt.% of Sn, 0.05-0.16wt.% of As, with the balance being Zn and unavoidable impurities, and the zinc equivalent X meets the requirement of the following formula: 35% < X < 39.5%, wherein X= (B+ ∑ CiKi) / (A+B+ ∑ CiKi), in the formula, X is the zinc equivalent of the brass, A is the content of copper (%), B is the actual content of zinc (%), Ci is the content of other alloy elements (%), CiKi is the corresponding zinc equivalent of various elements.

[0015] Preferably, the content of Cu in the brass alloy is: 62-64wt.%;

[0016] Preferably, the content of Pb in the brass alloy is: 0.1-0.25wt.%;

[0017] Preferably, the content of Al in the brass alloy is: 0.1-0.4wt.%;

[0018] Preferably, the content of As in the brass alloy is: 0.08-0.12wt.%;

[0019] Preferably, the zinc equivalent X meets the requirement of following formula: 36% < X < 39%.

[0020] Preferably, the brass alloy further comprises one or more elements selected from Ni, Fe, Si, P and B.

[0021] Preferably, the content of Ni in the brass alloy is: 0.05-0.5wt.%, preferably 0.05-0.2wt.%; the content of Fe is 0.02-0.2wt.%, preferably 0.05-0.1wt.%; the content of Si is 0.03-0.3wt.%, preferably 0.05-0.2wt.%; the content of P is 0.01-0.2wt.%, preferably 0.05 - 0.1 wt.%; and the content of B is less than 0.01wt.%, preferably 5-30ppm.

[0022] The present invention further provides another low cost lead-free dezincification-resistant brass alloy for casting, wherein the brass alloy contains 60-65wt.% of Cu, 0.05-0.25wt.% of Pb, 0.05-0.4wt.% of Al, 0.1-0.4wt.% of Sn, 0.05-0.16wt.% of As, with the balance being Zn and unavoidable impurities, and the zinc equivalent X meets the requirement of following formula: 35% < X < 39%, wherein X= (B+ ∑ CiKi) / (A+B+ ∑ CiKi), in the formula, X is zinc equivalent in the brass, A is the content of copper (%), B is the actual content of zinc (%), Ci is the content of other alloy elements (%), CiKi is the corresponding zinc equivalent of various elements.

[0023] Preferably, the content of Cu in the brass alloy is: 62-64wt.%;

[0024] Preferably, the content of Pb in the brass alloy is: 0.1-0.25wt.%;

[0025] Preferably, the content of Al in the brass alloy is: 0.05-0.3wt.%;

[0026] Preferably, the content of Sn in the brass alloy is: 0.1-0.3wt.%;

[0027] Preferably, the content of As in the brass alloy is: 0.08-0.12wt.%;

[0028] Preferably, the zinc equivalent X meets the requirements of following formula: 36% < X < 38.5%.

[0029] Preferably, the brass alloy further comprises one or more elements selected from Ni, Fe, Si, P and B.

[0030] Preferably, the content of Ni in the brass alloy is 0.05-0.5wt.%, preferably 0.05 ~ 0.2wt.%; the content of Fe is 0.02-0.2wt.%, preferably 0.05-0.1wt.%; the content of Si is 0.03-0.3wt.%, preferably 0.05-0.2wt.%; the content of P is 0.01-0.2wt.%, preferably 0.05-0.1 wt.%; and the content of B is less than 0.01wt.%, preferably 5-30ppm.

[0031] The present invention will be described in detail as blow.

[0032] The present invention provides a low cost lead-free dezincification-resistant brass alloy for casting, the brass alloy contains 60-65wt.% of Cu, 0.05-0.25wt.% of Pb, 0.05-0.8wt.% of Al, less than 0.1wt.% of Sn, 0.05-0.16wt.% of As, with the balance being Zn and unavoidable impurities, and the zinc equivalent X meets the requirement of following formula:35% <(B+ ∑ CiKi) / (A+B+ ∑ CiKi) < 39.5%; or the brass alloy contains 60-65wt.% of Cu, 0.05-0.25wt.% of Pb, 0.05-0.4wt.% of Al, 0.1-0.4wt.% of Sn, 0.05-0.16wt.% of As, with the balance being Zn and unavoidable impurities, and the zinc equivalent X meets the requirement of following formula: 35% <(B+ ∑ CiKi) / (A+B+ ∑ CiKi) <39.0%.

[0033] In the present invention, the low content of Cu makes the brass material low cost, the content of Cu is defined at 60-65wt.%. If the content of Cu is too low, then the dezincification is poor. If the content of Cu is too high, then the cost is high, and the brass has poor castability and cuttability. Preferably, the content of Cu is 62-64wt.%.

[0034] The addition of trace amount of Pb can improve the cuttability of the brass alloy, and also meets with AB1953 regulation, that is, the lead content of the material of parts of bathroom products should be less than 0.25wt.%, and NSF61 regulation that is the release amount of Pb into water of single product of bathroom products should be less than 5ppb.

[0035] The addition of Al can increase the fluidity of the alloy, improve its castability, and has solid solution strengthening effect, thereby improving the strength of the alloy. However, when the Al content is too high, the β phase will precipitate, thereby affecting the dezincification resistance performance.

[0036] The addition of Sn can enhance the corrosion resistance, improve the castability, and decrease the defects such as blowhole, porosity and the like in the casting, but the content of Sn should not be too high, otherwise the cost of the alloy will be increased and the dezincification corrosion resistance will also be weakened, furthermore, when the content of Sn in the alloy is above 0.1wt.%, the zinc equivalent should be less than 39.0%, which can stabilize the dezincification corrosion resistance of the alloy.

[0037] The addition of trace amount of As can significantly improve the dezincification resistance of the alloy. However, the casting or forging cannot completely meet the requirements of AS 2345 only by adding arsenic, a certain heat treatment still be needed. In order to alleviate the tendency of dezinnation corrosion, the arsenic brass products are heated to the temperature above the α phase solubility curve to make the β phase dissolve into the α phase, then rapidly cooled to the temperature below the α phase solubility curve to perform the solid solution treatment to make all β phase disappear or change the distribution form of the β phase (from reticulation or strip to detached island). When the content of arsenic is too low, the dezincification-resistant performance cannot be improved significantly, when the content of arsenic is too high, the dezincification-resistant performance is not so good as that added the equivalent amount of As, the metal release is easy to exceed the standard. Preferably, the content of As is 0.08-0.12wt.%.

[0038] One or more elements selected from Ni, Fe, Si, P and B may be added to the dezincification-resistant brass alloy according to the present invention. Wherein, Ni can increase the ratio of α phase and improve the corrosion resistance of the alloy; the addition of a proper amount of Si can significantly improve the cuttability and castability of the alloy, that's because that Si mainly dissolves in the β phase and makes the β phase brittle, thus, the chips are easily broken when the cutting tool meets the β phase in the process of cutting. However, Si has large zinc equivalent and high content of Si will harm the dezincification-resistant performance of alloys. Proper amount of Fe, P and B can refine the grains and improve the dezincification-resistant performance of the alloys, but the much higher content of Fe will affect the action on improving dezincification-resistance and polishing performance brought by As. Preferably, the content of Ni is 0.05-0.5wt.%, the content of Fe is 0.02-0.2wt.%, the content of Si is 0.03-0.3wt.%, the content of P is 0.01-0.2wt.%, and the content of B is <0.01wt.%.

[0039] The most significant technical feature of the present invention is the introduction of zinc equivalent $X= (B+ \sum CiKi) / (A+B+ \sum CiKi)$, in the formula, X is zinc equivalent in the brass, A is the content of copper (%), B is the actual content of zinc (%), Ci is the content of other alloy elements (%), CiKi is the corresponding zinc equivalent of various elements. The dezincification corrosion of brass is related to the zinc content in Cu - Zn alloy, when the zinc content is lower than 15wt.%, the dezincification corrosion hardly occurs, but the erosion resistance of the alloy is poor, the increase of zinc content benefit to improve the strength and erosion resistance of the alloy, but increase the tendency of dezincification corrosion. When the zinc content of brass is more than 20 wt.%, the zinc element is easy to dissolve in the aqueous solution leaving the porous copper, which results in decreasing the strength of the brass, thereby greatly shortening the service life of the components working in the water. Therefore, the present invention defines the zinc equivalent of the alloy, only the above alloy formula is satisfied and the zinc equivalent is in a specific range (when the Sn content is less than 0.1wt.% in the alloy, the zinc equivalent should be 35.0-39.5%, while the Sn content is above 0.1wt.% in the alloy, the zinc equivalent should be 35.0-39.0%), the alloy has excellent dezincification-resistant performance and desirable castability.

[0040] The alloy according to the present invention has the characteristics of low cost, excellent dezincification corrosion resistance, good castability, good polishing and welding performance.

[0041] Specifically, compared with the prior art, the brass alloy according to the present invention at least possesses the following beneficial effects:

The brass alloy according to the present invention comprises no toxic elements such as cadmium, meanwhile, trace amounts of lead and arsenic are added, the release amount of the alloy elements into water meets the standard of NSF and AS/NZS 4020, therefore, the alloy is lead-free and environmentally friendly.

[0042] The brass alloy according to the present invention has excellent dezincification corrosion resistance, meets the requirements of AS 2345, and the average dezincification layer depth is $\leqq 100\mu m$.

[0043] The copper content in the brass alloy according to the present invention is relatively low, and the raw material of the alloy is cheaper compared with the lead-free DR brass in the market.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0044] The technical solution of the present invention will be further illustrated with the following examples which given as below are only for clarifying the present invention, not for limiting the scope of the present invention.

Example 1

[0045] Table 1 shows the composition of the alloys according to the examples of the present invention, and table 2 shows the composition of Alloy 1-9 used for comparison, wherein, the Alloy 1 used for comparison is lead brass CuZn39Pb1Al and the Alloy 2 used for comparison is DR brass CuZn35Pb2Al.

[0046] The performance testing of the above examples and the alloys used for comparison are performed below. Specific testing items and basis are as follows:

1. Castability

[0047] Volume shrinkage test samples: The test samples were used for measuring the concentrating shrinkage cavity, dispersing shrinkage cavity and shrinkage porosity. If the face of the concentrating shrinkage cavity for volume shrinkage test samples is smooth, there is no visible shrinkage porosity, and there is no visible dispersing shrinkage cavity in the test samples' cross section, it indicates the castability is excellent, and will be shown as "O". If the face of the concentrating shrinkage cavity is smooth but the height of visible shrinkage porosity is less than 5 mm in depth in the bottom of the concentrating shrinkage cavity, there is no visible dispersing shrinkage cavity in the test samples' cross section, it indicates castability is good, and will be shown as "Δ". If the face of the concentrating shrinkage cavity is not smooth and the height of visible shrinkage porosity is more than 5 mm in depth in the bottom of the concentrating shrinkage cavity, it will be shown as "x".

[0048] Spiral test samples: The test samples were used for measuring the melt fluid length and evaluating the fluidity of the alloy.

[0049] Strip test sample: The test samples were used for measuring linear shrinkage of alloys.

2. Mechanical performance

[0050] The mechanical performance of the alloys were tested according to GB/T228-2010, both the alloys according to the present invention and the alloys used for comparison were processed into standard test samples with a diameter of 10mm and the tensile test was conducted at room temperature to test the mechanical performance of each alloy.

3. Cuttability

[0051] The cutting test was carried out on a horizontal lathe, and the shape of the chips was used to evaluate the cuttability of the alloys. Both the alloys according to the present invention and the alloys used for comparison were turned under the same condition, and the chips in fine and short needles will be considered as best, represented by "○"; the chips in fine short scrolls and fan-shape will be considered as good, represented by "Δ" ; and the chips in long scrolls will be considered as bad, represented by "×".

[0052] The testing results of castability, mechanical performance and cuttability of some of the alloys according to the present invention and the alloys used for comparison were shown in table 3.

4. Dezincification corrosion resistance

[0053] The dezincification test was conducted according to AS2345, and three parallel samples with the sectional dimension of 10mm × 10mm were obtained by cutting the thickest part of the casting made from the alloys according to the present invention and the alloys used for comparison. The inlayed test samples were placed in copper chloride solution with temperature controlled at 75 ± 3°C for corrosion at constant temperature for 24 hours, then the samples were cut into slices and made into metallographic microscope and the average depth of the dezincification layer was calibrated.

[0054] The results of the depth of the dezincification layer of the alloys according to the present invention and the alloys used for comparison were shown in tables 1 and 2.

Table 1 Components of Alloys According to the Present Invention (wt.%)

Alloy	Cu	Al	Sn	Ni	Fe	Si	P	As	Pb	B	Zn	Zinc equivalent X (%)	Average depth of the dezincification layer (μm)
1	62.40	0.19						0.12	0.12		balance	38.09	24
2	61.81	0.38						0.12	0.14	5ppm	balance	39.22	34
3	64.39	0.76						0.11	0.12		balance	37.87	58
4	62.98	0.27						0.09	0.16	12ppm	balance	37.73	4
5	63.10	0.24						0.11	0.19	13ppm	balance	37.49	18
6	64.15	0.05		0.16				0.09	0.12	5ppm	balance	35.85	22
7	63.99	0.53			0.05			0.09	0.19	8ppm	balance	37.54	26
8	61.95	0.30	0.20					0.12	0.11	7ppm	balance	38.97	72
9	62.76	0.28	0.11					0.11	0.12	10ppm	balance	38.07	50
10	63.89	0.24	0.27			0.13	0.06	0.10	0.13	15ppm	balance	37.62	2
11	62.86	0.10	0.39			0.19	0.04	0.09	0.25	9ppm	balance	38.62	49

Table 2 Components of Alloys Used for Comparison (wt.%)

Alloy	Cu	Al	Sn	As	Pb	B	Zn	Zinc equivalent X (%)	Average depth of the dezincification layer (μm)
1 (CuZn39Pb1Al)	60.25	0.55			1.45	19ppm	balance	41.36	430
2 (CuZn35Pb2Al)	63.91	0.67	0.25	0.10	1.83	17ppm	balance	38.20	61
3	62.19	0.72		0.11	0.12		balance	39.87	393
4	64.02	0.82		0.11	0.12		balance	38.22	105
5	61.10	0.19	0.31	0.12	0.05	14ppm	balance	39.48	260
6	62.10	0.65	0.12	0.12	0.13		balance	39.83	239
7	63.5	0.81	0.11	0.11	0.12	<5ppm	balance	38.94	157
8	61.45	0.59	0.09	0.12	0.12	9ppm	balance	40.20	189
9	61.91	0.43	0.21	0.09	0.15	12ppm	balance	39.39	109

[0055] It can be seen from table 1 and 2 that the average depth of the dezincification layer of the alloys according to the present invention are all less than 100μm, which are significantly superior to Alloy 1 and Alloys 3-9 used for comparison, and it is revealed by the relationship between the zinc equivalent and the depth of the dezincification layer of the alloys according to the present invention and the alloys used for comparison that only when the content of Sn element in the alloys according to the present invention is less than 0.1wt.% and the zinc equivalent meets 35% < equivalent weight of zinc X < 39.5%, or the content of Sn element in the alloys according to the present invention is no less than 0.1wt.% and the zinc equivalent meets 35% < equivalent weight of zinc X < 39.0%, the average depth of the dezincification layer can be guaranteed within 100μm.

Table 3 The Castability and Mechanical Performance of Tested Alloys

Alloy Nos.	Castability			Mechanical Performance			Cuttablity
	Volume Shrinkage	Linear shrinkage/ %	Fluidity/mm	Tensile strength/MPa	Elongation/ %	Brinell hardness	
Alloy 1 according to the present invention	○	1.93	540	430	40	82	×
Alloy 2 according to the present invention	○	1.65	510	450	39	83	Δ
Alloy 3 according to the present invention	Δ	1.90	540	380	55	78	×
Alloy 4 according to the present invention	○	1.68	505	420	42	79	×

(continued)

Alloy Nos.	Castability			Mechanical Performance			Cuttablity
	Volume Shrinkage	Linear shrinkage/ %	Fluidity/mm	Tensile strength/MPa	Elongation/ %	Brinell hardness	
Alloy 5 according to the present invention	○	1.69	410	415	40.0	81	×
Alloy 6 according to the present invention	○	1.88	520	365	56.5	78	×
Alloy 7 according to the present invention	○	1.94	395	369	57.0	76	×
Alloy 8 according to the present invention	○	1.73	550	410	54	80	×
Alloy 9 according to the present invention	Δ	1.70	550	355	53	69	×
Alloy 10 according to the present invention	○	1.60	550	372	57	78	Δ
Alloy 11 according to the present invention	○	1.58	550	380	58	79	Δ
Alloy 1 used for comparison	○	1.82	405	345	11.5	65	○
Alloy 2 used for comparison	Δ	1.80	430	335	19.0	76	○

[0056] It can be seen from table 3 that the castability of the alloys according to the present invention is comparable to that of lead DR brass, but as regard to mechanical performance, the tensile strength and elongation rate of the alloys according to the present invention are all higher than those of lead copper and lead DR brass.

[0057] It can be seen from all the above results that the alloys according to the present invention possess excellent dezincification corrosion resistance and comprehensive performance, and good castability and mechanical performance as well. Meanwhile, the release amount of toxic metal elements of the alloys according to the present invention into water meets the requirements of NSF and AS/NZS 4020 detecting standards, the alloys according to the present invention belong to environment-friendly materials. Therefore, the alloys according to the present invention have more extensive market application prospect.

[0058] The examples above are described for the purpose of illustration and not intend to limit the present invention. Within the spirit and the scope of protection defined by claims of the present invention, any modifications and changes made to the present invention fall into the scope of protection of the present invention.

Claims

1. A low cost lead-free dezincification-resistant brass alloy for casting, wherein the brass alloy contains 60-65wt.% of Cu, 0.05-0.25wt.% of Pb, 0.05-0.8wt.% of Al, less than 0.1wt.% of Sn, 0.05-0.16wt.% of As, with the balance being Zn and unavoidable impurities, and the zinc equivalent X meets the requirement of following formula: 35% < X < 39.5%, wherein X= (B+ ∑ CiKi) / (A+B+ ∑ CiKi), in the formula, X is the zinc equivalent of the brass, A is the content of copper (%), B is the actual content of zinc (%), Ci is the content of other alloy elements (%), CiKi is the corresponding zinc equivalent of various elements.

2. The brass alloy according to claim 1, wherein the content of Cu in the brass alloy is: 62-64wt.%;
preferably, the content of Pb in the brass alloy is: 0.1-0.25wt.%.

3. The brass alloy according to claim 1 or 2, wherein the content of Al in the brass alloy is: 0.1-0.4wt.%;
preferably, the content of As in the brass alloy is: 0.08-0.12wt.%;

4. The brass alloy according to any one of claims 1 to 3, wherein the zinc equivalent X meets the requirement of following formula: 36% < X < 39%.

5. The brass alloy according to any one of claims 1 to 4, wherein the brass alloy further contains one or more elements selected from Ni, Fe, Si, P and B; Preferably, the content of Ni in the brass alloy is: 0.05-0.5wt.%, preferably 0.05-0.2wt.%; the content of Fe is 0.02-0.2wt.%, preferably 0.05-0.1wt.%; the content of Si is 0.03-0.3wt.%, preferably 0.05-0.2wt.%; the content of P is 0.01-0.2wt.%, preferably 0.05-0.1 wt.%; and the content of B is less than 0.01wt.%, preferably 5-30ppm.

6. A low cost lead-free dezincification-resistant brass alloy for casting, wherein the brass alloy contains 60-65wt.% of Cu, 0.05-0.25wt.% of Pb, 0.05-0.4wt.% of Al, 0.1-0.4wt.% of Sn, 0.05-0.16wt.% of As, with the balance being Zn and unavoidable impurities, and the zinc equivalent X meets the requirement of following formula: 35% < X < 39%, wherein X= (B+ ∑ CiKi) / (A+B+ ∑ CiKi), in the formula, X is zinc equivalent of zinc in the brass, A is the content of copper (%), B is the actual content of zinc (%), Ci is the content of other alloy elements (%), CiKi is the corresponding zinc equivalent of various elements.

7. The brass alloy according to claim 6, wherein the content of Cu in the brass alloy is: 62-64wt.%;
preferably, the content of Pb in the brass alloy is: 0.1-0.25wt.%.

8. The brass alloy according to claim 6 or 7, wherein the content of Al in the brass alloy is: 0.05-0.3wt.%;
preferably, the content of Sn in the brass alloy is: 0.1-0.3wt.%;
preferably, the content of As in the brass alloy is: 0.08-0.12wt.%.

9. The brass alloy according to any one of claims 6 to 8, wherein the zinc equivalent X meets the requirements of following formula: 36% < X < 38.5%.

10. The brass alloy according to any one of claims 6 to 9, wherein the brass alloy further contains one or more elements selected from Ni, Fe, Si, P and B; preferably, the content of Ni in the brass alloy is 0.05 - 0.5wt.%, preferably 0.05 ~ 0.2wt.%; the content of Fe is 0.02-0.2wt.%, preferably 0.05-0.1wt.%; the content of Si is 0.03 - 0.3wt.%, preferably 0.05-0.2wt.%; the content of P is 0.01-0.2wt.%, preferably 0.05-0.1 wt.%; and the content of B is less than 0.01wt.%, preferably 5-30ppm.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/111286

A. CLASSIFICATION OF SUBJECT MATTER

C22C 9/04 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C 9

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, WPI, EPODOC, CNKI: copper, Cu, lead, Pb, aluminum, Al, tin, Sn, arsenic, As, zinc, Zn, nickel, Ni, iron, Fe, silicon, Si, phosphorus, P, boron, B

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 105543548 A (XIAMEN LOTA INTERNATIONAL CO., LTD.), 04 May 2016 (04.05.2016), claims 1-10	1-10
X	CN 102312123 A (ZHEJIANG IDC FLUID CONTROL CO., LTD.), 11 January 2012 (11.01.2012), claim 1	1-10
X	CN 103469004 A (YORHE FLUID INTELLIGENT CONTROL CO., LTD.), 25 December 2013 (25.12.2013), claim 2	1-10
X	CN 104745863 A (JOMOO KITCHEN & BATH CO., LTD.), 01 July 2015 (01.07.2015), embodiment 1	1-10
PX	EP 3050983 Al (TOTO LTD.), 03 August 2016 (03.08.2016), claim 1	1-10
A	TW 201100564 A (CHAN WEN COPPER IND CO., LTD.), 01 January 2011 (01.01.2011), the whole document	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 February 2017 (07.02.2017)	**23 March 2017 (23.03.2017)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **WU, Chenchen** Telephone No.: (86-10) **62084743**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/111286

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 105543548 A	04 May 2016	None	
CN 102312123 A	11 January 2012	None	
CN 103469004 A	25 December 2013	CN 103469004 B	02 December 2015
CN 104745863 A	01 July 2015	None	
EP 3050983 A1	03 August 2016	CN 105821240 A	03 August 2016
		US 2016215366 A1	28 July 2016
		JP 2016145411 A	12 August 2016
		JP 6056947 B2	11 January 2017
TW 201100564 A	01 January 2011	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 201110389789 **[0006]**
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- CN 200910164116 **[0008]**
- CN 200910171021 **[0009]**
- CN 201010502728 **[0010]**
- GB 2282010 T **[0050]**